

Patent Application

for

AUTOMATIC STEREO / MONAURAL HEADPHONE

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RELATED APPLICATION

This application claims the benefit of Provisional Application Number 60/212,807 filed June 19, 2000 entitled AUTOMATIC STEREO / MONAURAL HEADPHONE.

BACKGROUND OF THE INVENTION

This invention relates to headphones designed primarily for classroom use in the education environment. A great variety of audio and audio-visual equipment is now commonly employed for instructional purposes in school classrooms. The use of headphones for students to listen to instructional audio material is often desirable in order to provide a noise-free private environment for individual and small group instruction. These audio sources include study carrels, phonographs, tape players, compact disk players, video displays, film projectors, and computers. The audio sources commonly employed in the education environment may be monaural or stereo and are often accessed by a single jack that accepts only a 1/8-inch or a 1/4-inch headphone plug. This has resulted in difficulty for teachers and equipment custodians to stock and maintain control of headphone equipment for use with all of these various audio sources.

PRIOR ART

Existing headphone designs for accessing the various audio sources described above are shown in Fig. 1 and Fig. 2. Fig. 1A discloses a headphone 10 that includes left and right earpieces 12 and 14 respectively, a connection cord 18 terminated in a stereo plug 16 and an "in-line" switch 20 to select a stereo or monaural source. Fig. 1B is a circuit diagram showing the switch 20 set for a stereo source. It shows a common connection from the plug sleeve-contact 22 to like identified terminals (+) of the two earpiece drivers 13 and 15. The plug ring-contact 24 is connected to the other identified terminal (-) of the left earpiece driver 13 and the plug tip-contact 26 is connected to the corresponding identified terminal (-) of the right earpiece driver 15. This setting provides normal stereo listening from a stereo source. Fig. 1C shows the circuit diagram with the switch 20 set to access a monaural source. There is no connection to the plug 16 ring-contact 24. The plug 16 tip-contact 26 is connected to the (-) terminals of the earpiece drivers 13 and 15. This allows a monaural source to be heard in both ears. A plug adapter 28 provides access to audio sources that accept only a 1/4-inch plug.

Although a headset with a mono/stereo selection switch would require only the addition of a single stereo plug adapter to change the headset plug size, the use of such a switch for selecting a monaural or stereo source has not found favor in the education environment for the following reasons:

1. The selection switches are likely to be played with by the students and have not proved to have the ruggedness and reliability required for classroom use, and;
2. The source must be positively identified prior to making a switch selection.
3. Teachers prefer to configure the headset for the proper source when used by younger children so they cannot easily change it to the wrong configuration.

Fig. 2 discloses additional prior art for a headphone system that can access either a monaural or stereo audio source that accepts only a 1/4-inch or 1/8-inch plug. **Fig. 2A** shows a stereo headset **30** consisting of an adjustable headband **32**, left and right earpieces **34** and **36** respectively, connection cord **38** terminated in a molded plug assembly **40** that includes a 1/8-inch stereo plug **42**. The plug **42** includes external screw threads **58** that mate with internal screw threads of three plug adapters **44**, **46** and **48**. A plastic holder **50** for the plug adapters is secured to the connection cord **38** to store them when not in use. These plug adapters are shown enlarged in outline drawings in **Fig. 2C**. **Fig. 2B** is a schematic diagram of the headset for accessing a stereo source with the 1/8-inch stereo plug **42**. The ring-contact **54** is connected to the (-) terminal of the left earpiece driver **35** and the tip-contact **56** is connected to the (-) terminal of the right earpiece driver **37**. A connection to the (+) terminal of each earpiece driver is made to the sleeve-contact **52** of the plug **42**.

Plug adapter **44** shown in **Fig. 2C** converts the headset **30** for listening to a monaural source equipped with a 1/4-inch output jack. It connects the tip-contact **60** to both the tip-contact **56** and to the ring-contact **54** of the stereo plug **42** shown in **Fig. 2B** thus allowing the audio source to be heard at both earpieces **34** and **36** of the headset. Sleeve-contact **62** connects the source sleeve circuit to sleeve-contact **52** of plug **42**. Similarly plug adapter **46** provides for listening to a monaural source equipped with a 1/8-inch output jack. It connects the tip-contact **64** to both the tip-contact **56** and to the ring-contact **54** of the stereo plug **42** shown in **Fig. 2B** thus allowing a monaural audio source equipped with a 1/8-inch output jack to be heard at both earpieces **34** and **36** of the headset.

Plug adapter **48** shown in **Fig. 2C** adapts the 1/8-inch stereo plug **42** of the headset to a stereo source equipped with a 1/4-inch stereo jack. It connects the tip-contact **68**, the ring-contact **70**, and the sleeve-contact **72** to their respective contacts **56**, **54** and **52** of plug **42** thus providing for normal stereo listening to the source.

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SUMMARY OF THE INVENTION

The headphone design of this invention accesses a monaural or stereo source with a connection cord preferably terminated in a 1/8-inch stereo plug. In a first embodiment of the invention the right and left signals from a stereo source are connected in a normal manner directly to each earpiece driver; that is, the right channel is connected to an identified terminal of one (usually the right) earpiece driver, and the left channel is connected to a similarly identified terminal of the other earpiece driver. A common connection from the stereo source is connected to the other terminal of each earpiece driver. In this embodiment of the invention a connection is also made between the right and left channel identified terminals of the earpiece drivers through an impedance element. The magnitude of the impedance element is chosen with respect to the impedance of the earpiece drivers such that an audio signal appearing at only one earpiece driver terminal, as would be the case with a monaural source, is coupled to the other earpiece driver with a reduction in signal strength at the other earpiece driver terminal of the order of two decibels. This slight reduction in loudness in one ear is virtually imperceptible to the listener, probably aided by a psycho-acoustical effect that masks the slight reduction in loudness in one ear if the other ear suffers no reduction in loudness.

The impedance element results in a slight mixing of right and left channel audio signals from a stereo source. The amount of channel mixing described above is so small that stereo separation is virtually unaffected and no reduction of stereo imaging is perceptible to the listener. The reason for this small amount of channel mixing is the typical low impedance of the audio sources compared to the value of the impedance element; a ratio of about one hundred. This results in the crosstalk between channels caused by the impedance to be about 40 decibels below the level of either channel, a level well below the channel separation requirement for good stereo performance.

In a second embodiment of the invention the stereo channel that is connected to the ring contact of the stereo plug is connected directly to one earpiece driver and the other channel that is connected to the tip of the stereo plug is connected to each earpiece driver

through a an impedance element. A monaural source is always accessed by the plug tip, and thus each earpiece driver is connected to the source through one of the impedance elements. If each impedance element is one-half the value of the impedance element used in the first embodiment described above the monaural signal will be heard at each earpiece with equal
5 loudness at a level of the order of one decibel less than if a direct connection to each earpiece driver had been made as in a conventional stereo headset. With a stereo source one channel will be heard with no reduction in loudness compared to a conventional stereo headset and the other channel will be heard with reduced loudness of the order of one decibel. This slight difference in the level of the stereo channels is not perceptible and can be easily balanced, if
10 desired, by a balance control available with many stereo sources. Again, because of the typical low impedance of the stereo source, the stereo crosstalk due to the coupling impedance elements is about -34 decibels, providing excellent stereo performance.

Thus the headset can be used with either a monaural or stereo source without requiring any action to identify the nature of the source or configure the headset for the type of audio
15 source, while providing virtually the same efficacy of use as a separate headphones dedicated to either a monaural or stereo source, or a headphone provided with a mono/stereo switch selector, or a headphone employing stereo-to-mono plug adapters.

Accordingly, it is an object of the invention to provide a headphone that can be used for automatic listening to a monaural or stereo audio source, that does not have to be
20 configured for the type of audio source, and that provides for hearing with substantially equal loudness at both earpieces either a monaural signal or equal magnitude right and left channel stereo signals and with which the stereo source is heard with right and left channel separation and stereo imaging substantially as afforded by the stereo source.

It is a further object of this invention to provide at a lower cost than heretofore possible
25 a headphone that requires no switching means and only one plug adapter to access the four configurations of sources represented by a monaural or stereo source with either a single 1/8-inch or single 1/4-inch output jack.

BRIEF DESCRIPTION OF THE DRAWINGS

30 **Fig. 1** is a drawing of prior art showing a headphone that employs a Monaural-Auto selection switch to select a monaural or stereo audio source.

Fig. 2 is a drawing of prior art showing a headphone that employs plug adapters to select a monaural or stereo audio source.

Fig. 3 is a drawing of the present invention.

Fig. 4 is a schematic drawing of a first embodiment the present invention.

5 Fig. 5 is a schematic drawing of a first embodiment the present invention showing its connection to a monaural audio source.

Fig. 6 is a schematic drawing of a first embodiment the present invention showing its connection to a stereo audio source.

Fig. 7 is a schematic drawing of a second embodiment the present invention.

10 Fig. 8 is a schematic drawing of a second embodiment the present invention showing its connection to a monaural audio source.

Fig. 9 is a schematic drawing of a second embodiment the present invention showing its connection to a stereo audio source.

15 DESCRIPTION OF THE INVENTION

The invention is described with reference to **FIGs. 3-9**.

FIG. 3 shows what appears to be a conventional stereo headset **80** that includes an adjustable headband **82**, left earpiece **84**, right earpiece **86**, a connection cord **88** that is terminated in a 1/8 inch stereo plug **90**. A screw-on 1/8-inch to 1/4-inch stereo plug adapter **92** is provided with the headset. The adapter **92** is attached to the headphone cord **88** by bead-chain **91** to prevent it from becoming misplaced and lost. **FIG. 4** illustrates the internal construction of a first embodiment of the invention. The tip **98** of the stereo plug **90** is connected to the + terminal of the right earpiece driver **87** and the ring contact **96** of the stereo plug **90** is connected to the + terminal of the left earpiece driver **85**. The sleeve **94** of the stereo plug **90** is connected to the negative terminal of each earpiece driver. These are the normal connections of a conventional stereo headset. In this embodiment of the invention an impedance element consisting of a single resistor **100** is connected between the + terminals of the earpiece drivers, that is, from the plug tip **98** to the plug ring contact **96** of the stereo plug **20**. Therefore, the resistor can be located in the plug assembly **90**. In the construction shown in **FIG. 3** the connection cord enters the left earpiece **84** and connection to the right earpiece **86** is made by conductors passing through the headband **82**, thus allowing the resistor to be alternatively located in the left earpiece instead of in the plug assembly.

The value of the resistor **100** is selected with respect to the impedance of the earpiece driver **87** shown in **FIG. 4** such that the reduction in loudness at the left earpiece is acceptable to the listener. **FIG. 5** is a schematic diagram of a typical headphone employed in this invention when connected to a monaural audio source. For the earpiece driver R_D impedance of 300 ohms, the resistor R_1 is given a value of 100 ohms. This reduces the **MONAURAL SOURCE** signal level at the left earpiece to 75%, or about 2.5 decibels. On the basis of A/B tests with the resistor R_1 switched in or out, there was no perceptible difference in loudness among the listeners tested, and all listeners felt that they were hearing the monaural signal satisfactorily in both ears. Many listeners could detect a loudness reduction of one decibel when loudness is reduced in both ears or when listening with only one ear. Since the loudness ratio of one decibel was originally established as that representing the threshold of loudness difference perceptible to the human ear this is not a surprising result. It is believed that the imperceptibility of loudness reduction of 2 or 3 decibels at just one ear in the tests mentioned above results from a psycho-acoustic effect in which the brain masks this degree of loudness reduction if occurring at only one ear.

FIG. 6 is a schematic diagram of the embodiment of the invention shown in **FIG. 3** when plugged into a stereo source. It can be seen that the right and left channel stereo sources are connected directly to their respective earpiece drivers. The typical output impedance of the various audio sources cited above is of the order of one ohm, and that value is used in these illustrations. It can be shown that the stereo signals will be delivered to the earpiece drivers with negligible reduction (about 0.1 decibels) in loudness due to the 100-ohm resistor R_1 , compared to dedicated headphones .

The 100-ohm resistor R_1 will also couple some signal from each stereo channel into the other channel resulting in a small amount of crosstalk between channels. Such crosstalk tends to reduce the channel separation upon which stereo imaging is dependent. Stereo imaging depends upon both phase and delay differences as well as magnitude differences between channels and satisfactory imaging can be achieved with channel amplitude separation as little as 10 decibels. Because of the large ratio (100:1) of R_1 to the source resistance R_S , crosstalk contributed by the resistor R_1 is -40 decibels, and is virtually imperceptible.

FIG. 7 shows a second embodiment of the invention. In order to equalize the loudness at both ears when accessing a monaural source, the plug tip **98** of the stereo plug **90** is connected to each of the earpiece drivers **85** and **87** through resistors **102** and **104** that are of

equal value. The left earpiece driver **85** is directly connected to the ring contact **96** of the stereo plug **90**.

FIG. 8 is a schematic diagram of the second embodiment when accessing a monaural source. If the resistors **R₃** and **R₄** are each given 1/2 the value (50 ohms) of the resistor **R₁** (100 ohms) used in the first embodiment of the invention, the reduction in loudness at each earpiece is only 1.3 decibels, and the monaural signal is received with equal loudness at both earpieces.

FIG. 9 is a schematic diagram of the second embodiment of the invention when accessing a stereo audio source. Since the left channel receives the signal directly from the plug ring and the right channel receives the signal from the plug tip through the 50 ohm resistor **R₂** the right channel loudness is 1.3 decibels lower than the left channel. Again, this slight difference in loudness is not perceptible. Many stereo sources have a balance control that can adjust this small difference if it further contributes to a perceptible difference in channel balance. Crosstalk between channels is increased from -40 decibels of the first embodiment to -34 decibels, which still results in an imperceptible difference in stereo imaging.

Both embodiments of this invention described above exhibit excellent efficacy in providing a headset with automatic monaural/stereo listening that virtually equals the performance of an individual monaural or stereo headset or a single headset that can be configured by a switch or plug adapters to duplicate the performance of an individual monaural or stereo headset. The table below shows the differences in the performance between the two embodiments and individual headsets.

AUDIO SOURCE	RIGHT EARPIECE LOUDNESS		LEFT EARPIECE LOUDNESS		STEREO CROSSTALK	
	EMBODIMENT		EMBODIMENT		EMBODIMENT	
	1	2	1	2	1	2
Monaural	0 dB	-1.3 dB	-2.5 dB	-1.3 dB	NA	NA
Stereo	0 dB	-1.3 dB	0 dB	0 dB	-40 dB	-34 dB

From a theoretical viewpoint embodiment 1 may be preferred by those whose main interest is to maximize stereo performance, whereas others whose primary use involves monaural sources might prefer the slightly better loudness balance of embodiment 2. In either case, the choice would be very difficult to make based upon comparative listening tests.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that other embodiments are possible. It should be recognized that some variation could be made in the resistor values shown in the above illustrations without materially reducing the efficacy of this invention. Earpiece drivers that vary significantly from the examples shown above will require different impedance element values to preserve substantially the same ratios to the driver impedance as is shown in the illustrations of this disclosure. Depending upon the characteristics of the earpiece drivers it might be desirable to design the impedance element(s) 100, 102, and 103 shown in Figs. 4 and 7 as complex impedances rather than pure resistors by including inductive or capacitive components in them. Furthermore, while generally specific claimed details of the invention constitute important specific aspects of the automatic monaural/stereo headphone, in appropriate instances even the specific claims should be considered in light of the doctrine of equivalents.